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A new rust species of *Coleosporium* on *Ligularia fischeri* from China

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Abstract – *Coleosporium zhuangii*, a new species on *Ligularia fischeri*, is described from China. Light and scanning electron microscopy observation indicate that this species is morphologically distinct from other known *Coleosporium* species in urediniospore-surface structure, urediniospore shape and size, and the teliospore arrangement in telia.

Key words – *Uredinales*, rust fungus, taxonomy

Introduction

The rust genus *Coleosporium* Lév. consists of about 100 species worldwide (Kirk et al. 2008). Most species are heteroecious and macrocyclic and produce spermogonia and aecia on the needles of *Pinus* and uredinia and telia on various woody and herbaceous angiosperms (Laundon & Rainbow 1971, Kaneko 1981). The genus is characterized by mature teliospores in the telia dividing into four-celled internal basidia with or without a sterile cell at their base; the upper part of teliospores is covered with a gelatinous layer, while the urediniospores are morphologically identical to aeciospores of a given species (Kaneko 1975, 1977, 1981; Hiratsuka & Kaneko 1975, Mims & Richardson 2005). In the taxonomic studies of *Coleosporium,* species delimitation has been based primarily upon the telial host range, teliospore arrangement in telia, presence or absence of a sterile cell at the base of four-celled basidia, urediniospore shape and size, and urediniospore and aeciospore surface structure (Hiratsuka 1960, Kaneko 1981). Approximately 58 species are currently reported in China (Tai 1979, Pan et al. 1991, Cao & Li 1999, Yan et al. 2006, Zhuang et al. 2006).

Coleosporium ligulariae Thüm. was originally based on a specimen on *Ligularia sibirica* (L.) Cass. collected in Siberia. In China, the rust fungus on *Ligularia* host plants has frequently been identified as *C. ligulariae*, and Tai (1979) and

Zhuang (2003) recorded this rust on nine *Ligularia* species, i.e., *L. dictyoneura, L. lapathifolia, L. stenocephala, L. tussilaginea* var. *formosana, L. duciformis, L. przewalskii, L. tangutica, L. deltoidea,* and *L. veitchiana*. Gao et al. (1996) and Cao & Li (1999), who described in detail the urediniospore and teliospore morphology of *C. ligulariae* on *L. przewalskii, L. veitchiana,* and *Ligularia* sp., stated that the urediniospore was subglobose or broadly ovate, densely verrucose with annulate verrucae, and with a reticulum-spot on the surface, while the teliospore was cylindrical or clavate, 40–80 × 15–28 μm, arranged in more than two layers. However, reports on the *Coleosporium* occurring on *Ligularia fischeri* (Ledeb.) Turcz. from China were scarce in literature. During a morphological and phylogenetic study of *Coleosporium* spp. in China, light and scanning electron microscopy was made of herbarium specimens on *L. fischeri*, *L. duciformis*, *L. franchetiana*, *L. przewalskii*, *L. veitchiana,* and *L. intermedia*. Our observations indicated that the urediniospores and teliospores of the rust on *Ligularia fischeri* differed morphologically from those on other species of *Ligularia* and other known *Coleosporium* species. The rust is illustrated and described as new.

Materials and methods

Materials

A total of 42 specimens parasitic on *Ligularia* sp. and *Saussurea* sp. were used for morphological observation. Dried specimens examined were loaned from the following institutions: the Herbarium Mycologicum Academiae Sinicae, Beijing (HMAS); Mycological Herbarium, Inner Mongolia Agricultural University, Hohhot (HIM); Mycological Herbarium, Beijing Forestry University, Beijing (HMBF); Mycological Herbarium, Northwest Agricultural & Forestry University, Yangling, Shaanxi (HMNWFC). Fresh specimens were collected from various locations during July to September from 2007 to 2009 in China.

Morphological observations

For light microscopy observations, urediniospores and hand sections of telia were mounted in a drop of lactophenol-cotton blue solution on a microscopic slide. For each specimen, about thirty spores were randomly chosen and observed for the selected morphological features, by using a DMIL Inverted Bio-microscope (Leica, German). The urediniospores and teliospores dimensions were measured by Microview MVC TWAIN Image Analyzer software. LM images were made by digitizing 35 mm color slides and converted them to black and white; Adobe Photoshop CS4 was used to adjust image contrast and to compose the plates.

In preparation for examination of urediniospore surface structure by SEM, urediniospores were attached on aluminum stubs covered with double-adhesive tapes, and then coated with platinum-palladium at 25 nm thick by a Hitachi SCD-005 Sputter Coater. The coated specimens were observed under a Hitachi S-4200 scanning electron microscope (Hitachi, Tokyo, Japan) operated at 10 or 15 kV. SEM images were captured using Quartz PCI Software ver. 4.0, and the plates were composed with Adobe Photoshop CS4.

Taxonomic description

Coleosporium zhuangii C.M. Tian & C.J. You, **sp. nov.** Fig. 1

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Spermogoniis et aeciis ignotis; urediniis hypophyllis, sparsis, rotundatis, 0.2–0.6 mm diam., mox nudis, pulverulentis, aurantiaco-flavis; urediniosposis oblongo-ellipsoideis vel clavato-oblongis, 20.6–38.5 × 15.4–25.7 µm, episporio dense verrucosis, verrucis 0.6–1.0 µm latis, 0.3–0.6 µm altis; teliis hypophyllis, sparsis, rotundatis, 0.3–1.2 mm diam., rufo-aurantiacis; non-septatis teliosporis oblongo-cylindraceis vel ellipsoideis, 50.9–84.6 × 15.4–32.0 µm,

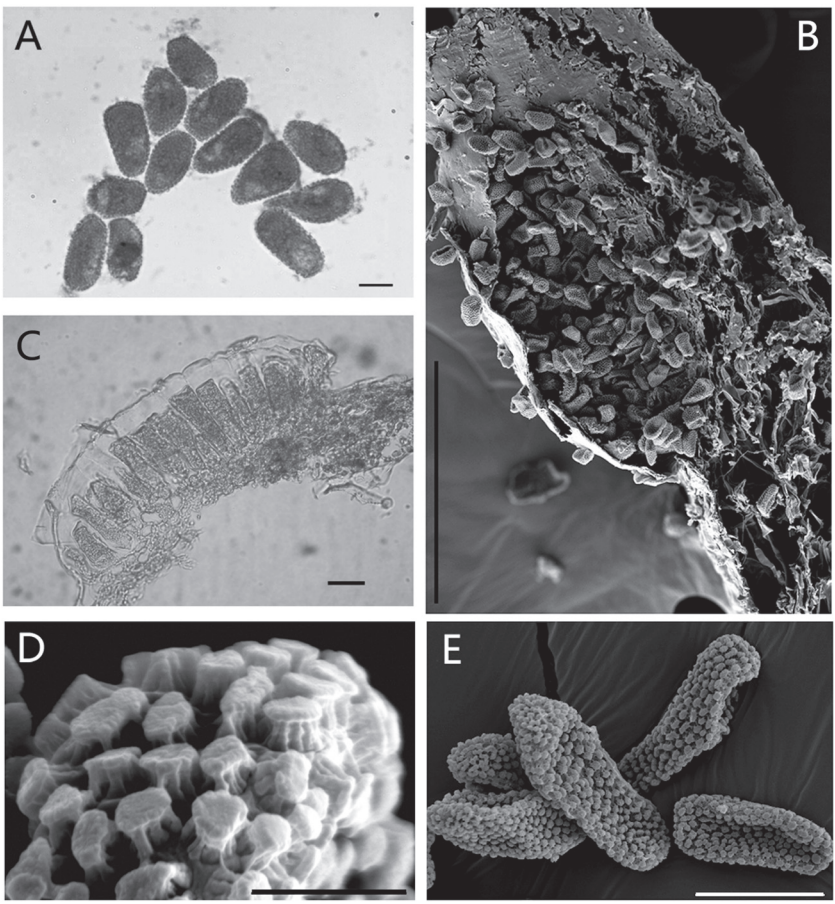

Fig. 1. *Coleosporium zhuangii* on *Ligularia fischeri* (HMAS-77787) A. Oblong-ellipsoid urediniospores observed by LM. (Bar = 10µm); B. Vertical section of telia (Bar = 20µm); C. Uredinia observed by SEM (Bar = 200µm); D. Urediniospores lacking a smooth or reticulum-like spot by SEM (Bar = 20µm); E. nailhead-like verrucae on urediniospore surface observed by SEM (Bar = 4µm).

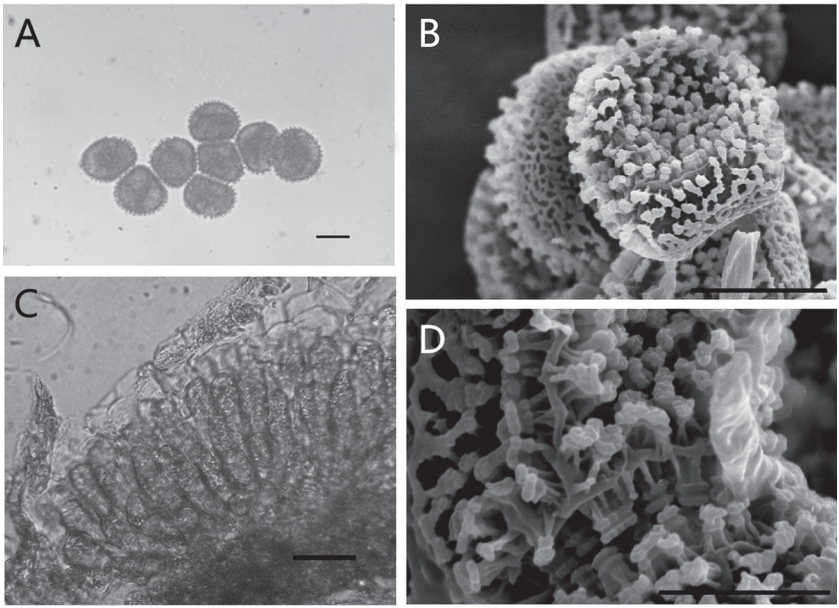

Fig. 2. *Coleosporium ligulariae* on *Ligularia duciformis* (HMAS-70985) A. Subglobose urediniospores observed by LM (Bar = 10μm); B. Vertical section of telia (Bar = 20μm); C. Urediniospores with a reticulum-like spot observed by SEM (Bar = 10μm); D. Annulate processes on urediniospore surface observed by SEM (Bar = 5μm).

tri-septatis basidiis 61.5–88.0 × 20.9–27.0 μm, transversim vel oblique septatis; membranis tenues, hyalinis; basidiosporis ellipsoideis, 17.3–26.8 × 12.2–17.2 μm.

Holotypus: *in foliis* Ligulariae fischeri *(*Compositae*), Bailang, Provincia Mongolia Interior, Sina, Aug. 1991, J. Y. Zhuang, HMAS-77787, in Herbario Mycologico Academiae Sinicae, Beijing (HMAS) conservatus.*

Etymology: the species is named in honor of Dr. J.Y. Zhuang, the collector of the examined specimens.

Spermogonia and aecia unknown. Uredinia hypophyllous, scattered, rounded, 0.2–0.6 mm diam., soon naked, pulverulent, orange-yellow; Urediniospores oblong-ellipsoid or clavate-oblong, 20.6–38.5 × 15.4–25.7 μm, densely verrucose, without a smooth or reticulum-like spot, verrucae 0.6–1 μm broad, 0.3–0.6 μm high; Telia hypophyllous, scattered, 0.3–1.2 mm diam., orange-red; One-celled teliospores long-cylindrical or ellipsoid, 50.9–84.6 × 15.4–32.0 μm excluding gelatinous apical layer, four-celled internal basidia 61.5–88.0 × 20.9–27.0 μm, transversely or obliquely septate, mature teliospores or basidia arranged in a single layer, wall thin, hyaline; Basidiospores ellipsoid, 17.3–26.8 × 12.2–17.2 μm.

Other specimens examined: II, III on *Ligularia fischeri*, Wuchagou, Inner Mongolia, China, Aug. 1991, S.X. Wei & J.Y. Zhuang, HMAS-77785; Arxan, Inner Mongolia, China, Aug. 1991, J.Y. Zhuang, HMAS-77786; Jagdaqi, Inner Mongolia, China, July 2000, J.Y. Zhuang, HMAS-82751; Arxan-yimin, Inner Mongolia, China, Aug. 1991, J.Y. Zhuang, HMAS-77788, 77789, 77797; Gyirong, Tibet, China, Sept. 1990, J.Y. Zhuang, HMAS-67451, 67456; Fuyuan, Heilongjiang, China, Aug.2004, J.Y. Zhuang, HMAS-135993. Raohe, Heilongjiang, China, Sept. 2003, J.Y. Zhuang, HMAS-89239.

Discussion

The present species is clearly distinct from *C. ligulariae* by its oblong-ellipsoid urediniospore (Fig. 1 A) and unique urediniospore-surface structure. The urediniospores (Fig. 1 D, E) are densely verrucose, lacking a smooth or reticulum-like spot on their surface, and the verrucae of urediniospores are nail-headed to peltate, 0.3–0.6 μm in height, 0.6–1.0 μm in width, with stilt-like bases connected by narrow longitudinal ridges. The broad heads of the verrucae are somewhat flat, but granulate with tiny papillae. In contrast, the verrucae of the subglobose urediniospores of *C. ligulariae* (Fig. 2 A, B, D) with a smooth or reticulum-like spot on their surface, are annulate, 0.5–0.9 μm high, and 0.3–0.5 μm broad, with two-layer annuli and stilt-like bases, the broad uneven tops of the verrucae are bumpy with pitted warts. In addition, the urediniospore size (20.6–38.5 × 15.4–25.7 μm) of *C. zhuangii* is larger than that of *C. ligulariae* (17.9–28.2 × 12.8–23.1 μm; 20.0–32.5 × 17.5–22.5 μm; Cao & Li 1999). Furthermore, the teliospores of *C. zhuangii* (Fig. 1 C) are generally arranged in a single layer, while those of *C. ligulariae* (Fig. 2 C) are frequently arranged in two or more layers.

Kaneko (1981) treated the *Coleosporium* on *Ligularia* spp. and *Saussurea* spp. in Japan as the same species, *C. saussureae* Thüm., through morphological observation and inoculation experiments. Thereafter, Kaneko et al. (1989) labeled a rust fungus on *Ligularia fischeri*, first recorded from Nepal, as *C. saussureae* based on the earlier (Kaneko 1981) taxonomic description. However, *C. saussureae* can be easily distinguished morphologically from the *C. ligulariae* on *Ligularia* spp. from Siberia by its somewhat larger urediniospores marked with reticulum-like spot on their surface and the basidia lacking a sterile cell. Gao et al. (1996) and Cao & Li (1999) suggested that the *C. ligulariae* from China is not synonymous to *C. saussureae* because of the differences in urediniospore size and surface structures. In *C. saussureae* the urediniospores are subglobose and 22.5–33.3 × 15.4–23 μm (20–35 × 14–22.5 μm, according to Cao & Li 1999), larger than those of *C. ligulariae.*

In this study, to some extent, the morphological features of *C. zhuangii* resemble those of *C. saussureae* on *Saussurea* spp. from China, but *C. zhuangii* differs in the shape of verrucae on urediniospore surface: *C. saussureae* has

globular urediniospores with a reticulum-like spot and thinner verrucae with cap-like tops.

The urediniospores of *C. campanulae* (Pers.) Lév. on *Adenophora* spp. and *Campanula* spp. are also have nail-headed verrucae that resemble those of *C. zhuangii*. However, *C. campanulae* can be distinguished from the present species by the smaller urediniospores with a greater number of verrucae per 100 μm^2 on the surface and the slender sterile cell at the base of telia. *Coleosporium campanulae* and *C. zhuangii* are also distinguished by having hosts exclusively in the *Campanulaceae* and the *Compositae*, respectively.

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